

On a new Type of Teleostean Cartilaginous Pectoral Girdle found in young Clupeids. By E. S. GOODRICH, F.R.S., Sec.L.S., Prof. of Comparative Embryology in the University of Oxford.

(With 6 Text-figures.)

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WHILE examining some thionin preparations of the cartilaginous skeleton of a young sprat, *Clupea sprattus*, caught at Plymouth*, I found that the pectoral girdle presented a quite unexpected structure, which seems to have hitherto escaped the notice of anatomists. On investigating the young of *Clupea harengus* and *C. pilehardus* the same peculiar form of girdle was found, and it may be considered as typical of the genus *Clupea*, and possibly may be found to occur in related genera.

In all living Teleostei the endoskeletal girdle, preformed in cartilage in the young, is in a reduced condition relatively to that of the large dermal bones which support it, and consists of right and left halves usually clearly separated in the middle line. Each half is firmly fixed to the cleithrum, and is formed of a short dorsal scapular region and of a generally much larger ventral coracoid region. These are separately ossified, and in many lower Teleostei, including the Clupeiformes, there is another ossification in a dorsal mesocoracoid arch, forming an inner buttress to strengthen the girdle near the articulation of the fin.

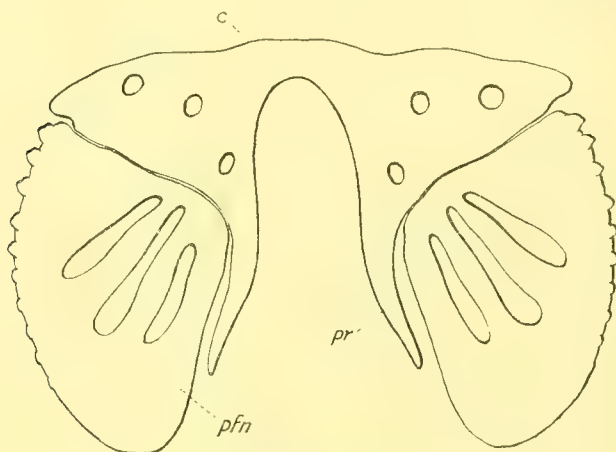
Although in many Teleosts the coracoids may be quite large, and may extend towards the middle line and meet, ventrally, yet, so far as I know, the left and right halves are always said to remain separate (3). Neither in the well-known monographs of Parker (5) and Gegenbaur (2), nor in the works of Stannius (6) and other authors, is there any mention of a median fusion of either cartilage or bone (the only possible exception I have met is that of two little ventral epicoracoid cartilages, widely separated from the coracoids, described by Parker as partially fused (5)). On the other hand, it is a familiar fact that in the Elasmobranchii and Dipnoi the two halves of the cartilaginous pectoral girdle, originally separate in the embryo, usually become firmly fused below the pericardium (3).

In the young Sprat, Herring, and Pilehard about 20 to 30 mm. in length, the endoskeletal pectoral girdle is in the form of a solid transverse bar of

* I am indebted to Miss Lebour for all the material on which this study is founded, and have to thank her for placing it at my disposal. The specimens were preserved in formol.

cartilage extending ventrally from side to side below the pericardium (figs. 1, 2, 3, & 5). At this stage the whole girdle consists of two slender dermal cleithra passing dorso-ventrally to meet below, and the cartilaginous

FIG. 1.



Clupea sprattus.

Cartilaginous skeleton of the pectoral fins and girdle.

FIG. 2.

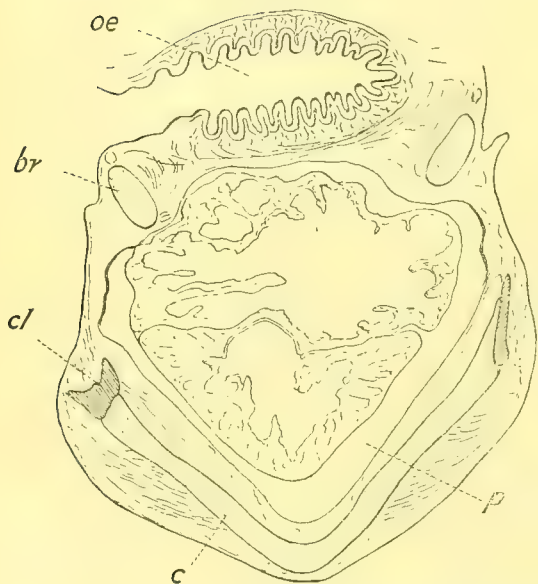
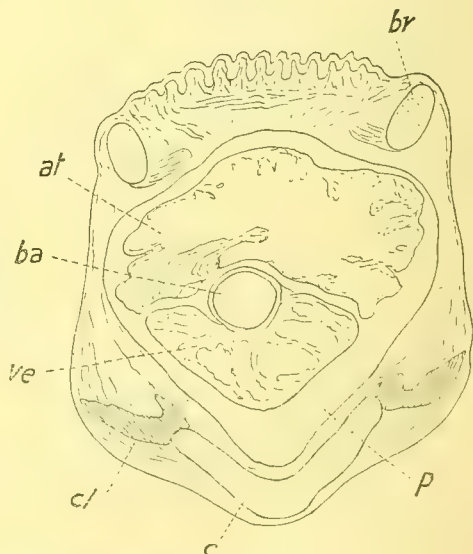


FIG. 3.

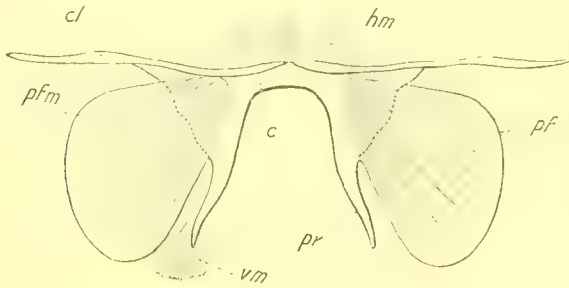


Clupea sprattus, 28 mm.

Fig. 2, transverse section showing the pectoral girdle below the pericardium.
Fig. 3, similar section further forward.

ventral bar expanding on either side into a triangular plate perforated by three foramina (fig. 4). These plates and the ventral bar represent the coracoid regions fused. On each side is a small latero-dorsal scapular process projecting in front of the fin-base; while a longer postero-ventral process extends backwards in the body-wall. At a little later stage, shown

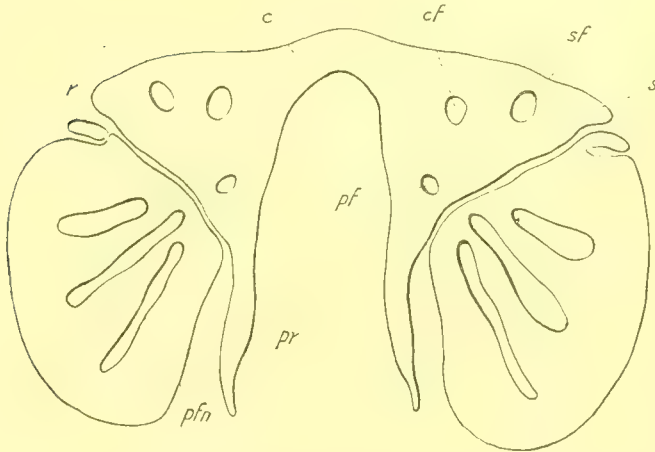
FIG. 4.



Clupea harengus, 30 mm.

Pectoral girdle and fins with muscles attached.

FIG. 5.



Clupea pilchardus.

Cartilaginous skeleton of the pectoral fins and girdle.

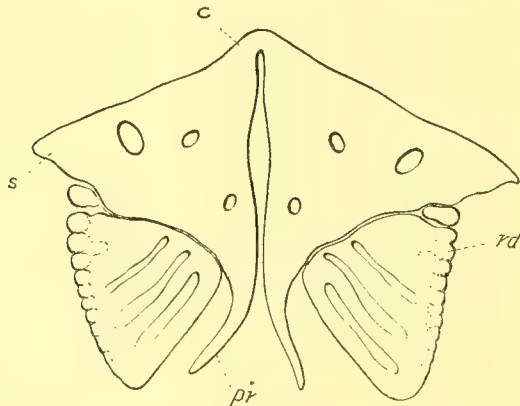
in fig. 6, the cross-bar becomes bent in the middle to form an acute angle pointing forwards, and at the bend the cartilage becomes absorbed so that the right and left halves soon are separated—a condition which, so far as I have been able to make out, persists in the adult.

The development of the pectoral girdle in Teleosts has been studied by Swirski (8) and Wiedersheim (10), and has lately been very completely

worked out by Swinnerton in *Salmo* and *Gasterosteus* (7), by Derjugin in *Exocoetus* (1), and by Haller and by Vogel in *Salmo* (4 & 9). These authors have ascertained that the endoskeletal girdle and fin-skeleton arise from paired rudiments widely separated. From each rudiment develops a procartilaginous plate in which become differentiated the fin radials and the girdle. The coracoid process of the latter grows downwards and forwards, and may even meet its fellow of the opposite side, without, however, fusing with it. A posterior process grows out behind, and subsequently dwindles and disappears in the adult. In *Clupea*, I find that the girdle arises in just the same way from paired rudiments, and that its subsequent history differs only in the formation of the transverse bar by fusion across the mid-ventral line.

As to what significance should be attached to the peculiar structure of the

FIG. 6.

*Clupea sprattus*, 36 mm.

Cartilaginous skeleton of the pectoral fins and girdle.

cartilaginous girdle in Clupeids described above, it would be rash to come to any definite conclusion before the corresponding stages in the development of allied forms have been studied. Two points may, however, be noticed:— (1) that the condition when the two halves form a continuous bar is transitory, the girdle being of paired origin and the halves separating again in later life when the dermal bones become well-developed; (2) that in no other Teleostomes, however primitive, do we find the paired elements of the girdle fused in the middle line. Therefore we can hardly suppose that the cross-bar represents an ancestral condition; rather would we suggest that it may be a specialisation due to the necessity of affording a firm base of support for the large pectoral fins in young Clupeids, which are active swimmers.

SUMMARY:—In the young of *Clupea sprattus*, *C. harengus*, and *C. pilchardus* about 20 to 30 mm. in length, the right and left coracoid regions fuse to a solid cartilaginous ventral bar, which becomes bent and again subdivided in later stages. This fusion is probably a specialisation to strengthen the support of the pectoral fins before the complete development of the dermal bones of the pectoral girdle.

REFERENCE-LETTERS FOR FIGURES 1-6.

at, atrium; *ba*, bulbus arteriosus; *br*, branchial arch; *c*, coracoid region; *cf*, coracoid foramen; *cl*, cleithrum; *hm*, hypoglossal muscles; *æ*, œsophagus; *p*, pericardium; *pf*, postcoracoid foramen; *pfm*, pectoral fin muscles; *pfn*, pectoral fin skeleton; *pw*, posterior process; *r*, radial; *rd*, distal radial cartilage; *s*, scapular process; *sf*, scapular foramen; *ve*, ventricle; *vm*, ventral body-wall muscle.

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